

Bulletin
o f t h e
Chicago Academy of Sciences

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The Chicago Academy of Sciences



C h i c a g o
Published by the Academy
1955

The Bulletin of the Chicago Academy of Sciences was initiated in 1883 and volumes 1 to 4 were published prior to June, 1913. During the following twenty-year period it was not issued. Volumes 1, 2, and 4 contain technical or semi-technical papers on various subjects in the natural sciences. Volume 3 contains museum reports, descriptions of museum exhibits, and announcements.

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In the fall of 1945, three living pit vipers that are conspicuously different from previously known members of Old World Crotalidae reached the National Zoological Park in Washington, D. C. They were obtained on Kume Shima, a small island some sixty miles westward off the southwestern end of Okinawa, Riu Kiu Islands, by Dr. Ernest R. Tinkham, then Captain, XXIV Sanitary Corps, H.Q. Mil. Govt., while on a brief leave for scientific collecting. Sent by air to the Army Medical Center, they were turned over to the zoo with Dr. Tinkham's request that eventually they be referred to me for study. They were examined by Dr. Doris M. Cochran of the U. S. National Museum who agreed that, by reason of their unusual and peculiar coloration, they should be investigated ; and subsequently, with the consent of the Surgeon General, they were forwarded to me by Dr. W. M. Mann, Director of the National Zoological Park.

Structurally these snakes are similar to *Trimeresurus flavoviridis flavoviridis* (Hallowell), known to natives of Okinawa as "Habu." I have compared them with twenty specimens of *flavoviridis* from the collections of the U. S. National Museum and the Chicago Natural History Museum and, on the basis of present knowledge, have concluded that they represent a subspecific population which may be known as

Trimeresurus flavoviridis tinkhami ssp. nov.

Figures 1-3

Diagnosis. General coloration grayish olive. Dorsal pattern a combination of irregular, variously coalescing, narrow stripes and spots, six to eight scales wide, along the middle of the body. Pattern of head indistinct or obsolescent. No pattern on sides. Ventral pattern absent or obsolescent.

Type Specimens. Holotype, U. S. National Museum 137285 male ; paratypes, U. S. N. M. 137286, female, and Chicago Natural History Museum 74895, female ; all from the north slope of mountains south of Higa, in southeast part of Kume Shima, Okinawa Group, Riu Kiu Islands ; obtained from native collector by Capt. Ernest R. Tinkham, Sanitary Corps, H. Q. Mil. Govt., XXIV Corps, in late August, 1945.*

Description of Holotype (Fig. 1). General form of body slender ; head large, conspicuously distinct from neck ; muzzle acute ; tail attenuated.

Muzzle flat, covered medianly with small, smooth, irregular scales (slightly injured anteriorly). Canthus moderately distinct, three canthal scales on each side, the middle one largest, all slightly recurved at outer margin. Supraoculars long, narrow, rounded posteriorly but becoming pointed anterolaterally and extending beyond orbit to the small third canthals. Area between supraoculars covered by 9 to 11 irregular rows of small, smooth scales which vary in size and resemble those covering the remainder of the dorsal part of the head ; a few in parietal region slightly enlarged.

Rostral triangular, acute at apex, about as wide as high. Pre- and postnasals in contact ventrally with first supralabial, which is triangular and extends backward and upward in a narrow point, almost touching loreal. One quadrangular loreal on each side. Preoculars two on each side, the upper larger and in broad contact with loreal, the lower narrow and extending forward and upward to form the upper posterior border of the maxillary pit. Postoculars small, two on each side. Lower posterior and ventral portion of orbit formed by a long, narrow, crescentic subocular ; total number of scales in orbit six on each side. Subocular separated from supralabials by a row of six small scales. Temporals smooth ; in four diagonal rows of 3, 3, 2, and 1 scales, those of the anterior row largest, those of the more posterior rows becoming progressively smaller as well as fewer.

Supralabials 9 on left side, 8 on right ; the second forming the anterior border of the pit, the third and fourth roughly triangular and conspicuously larger than those following posteriorly. An elongate, oval subfoveal extends diagonally above the third supralabial from the posterodorsal corner of the second supralabial almost to the anterior tip of

*Dr. Tinkham, in a letter to me dated June 23, 1946, wrote: "The native himself told me he found them by turning over logs and rocks up on the mountain side just south of Higa. He pointed out the mountain side to me when I got the snakes. . . . I had them over a month." He further stated that they ate half-grown dead rats and also mice, holding the mice in their jaws for five or more minutes until they were dead and then proceeding to swallow them.

subocular, thus forming the posteroventral border of the pit.

Infralabials 16 on left side, 16 on right ; relatively small and more nearly of uniform size, the sixth to tenth larger than the preceding. Mental triangular with a narrow point extending backward between the posterior tips of first supralabials which meet immediately beyond. One pair of genials, about two and one-half times as long as wide, with posterior ends terminating in attenuated points medially. Three pairs of smooth median gulars followed irregularly by five transverse rows of similar scales. Lateral gulars smooth, slender, in diagonal rows.

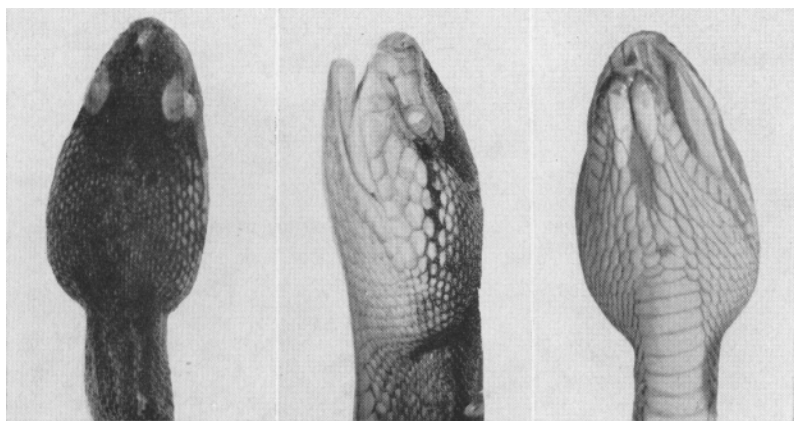


Figure 1. *Trimeresurus flavoviridis tinkhami*, holotype, USNM 137285, male, Higa, Kume Shima.

Scales of body narrow and pointed, with two apical pits; anteriorly those of 9 or 10 median dorsal rows keeled ; lateral rows becoming progressively keeled posteriorly until only lowermost lateral rows toward end of body are smooth. Scale rows 33-35-24, counted approximately one head-length posterior to head, at midbody, and immediately anterior to anus. Anal plate not divided.

Ventrals 226; subcaudals 84, all divided; tail apparently complete but terminal spine missing.

Total length 1540 mm., tail 245 mm.; tail/total-length ratio .159. Length of head 56 mm.; width of head 33 mm. (approx.).

General coloration dorsally grayish-olive, the darker pigmentation chiefly at periphery of individual scales; ventrally pale yellowish-orange

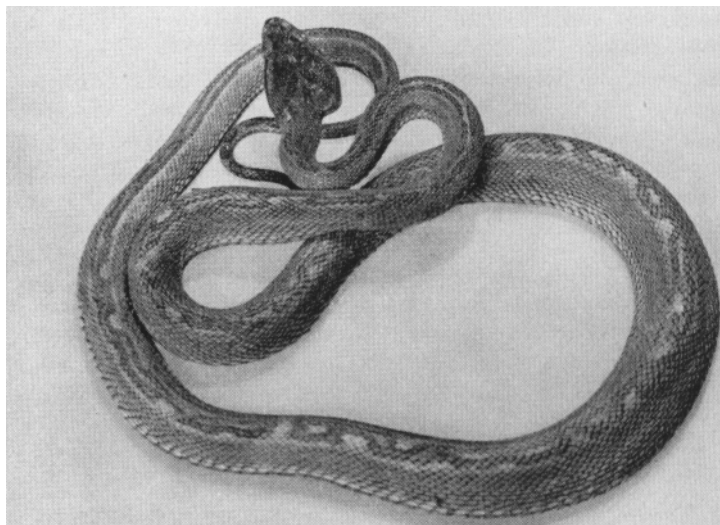


Figure 2. *Trimeresurus flavoviridis tinkhami*, paratype, USNM 137286, female, Higa, Kume Shima.

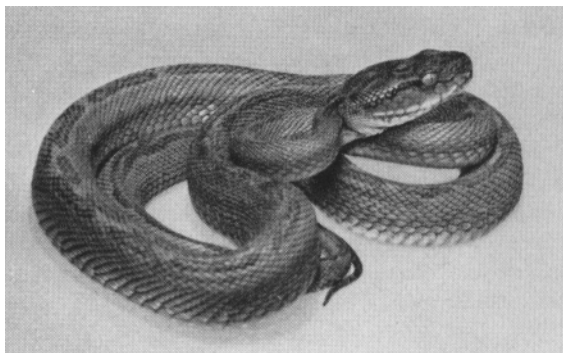


Figure 3. *Trimeresurus flavoviridis tinkhami*, paratype, CNHM 74895, female, Higa, Kume Shima.

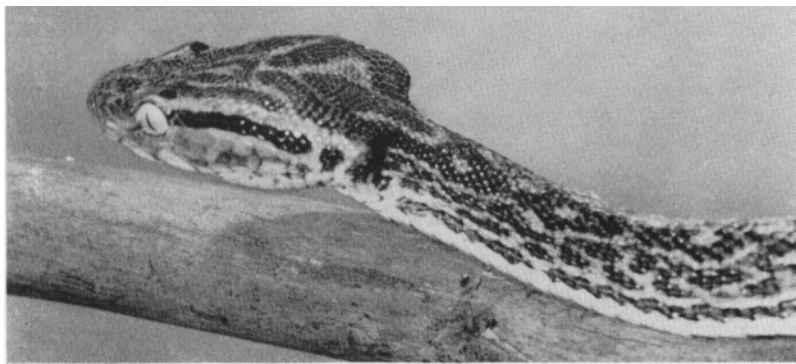


Figure 4. *Trimeresurus flavoviridis flavoviridis*, CNHM 74896, male, Okinawa Shima.



Figure 5. *Trimeresurus flavoviridis flavoviridis*, CNHM 74896, Okinawa.

When unconfined, all of these snakes showed a tendency to move upward on any available support. For this reason it was then inferred that they might be arboreal in habits. Further data received from Dr. Tinkham and notes published by Slater (1946), however, indicate that in some localities they inhabit rocky ledges along steep ravines.

in life, faded to pale cream in preservative. Top of head dark, the small scales appearing dark brown with light centers. An indistinct trace of a dark pattern visible in frontal and parietal regions. (See notes on paratypes for dorsal pattern of head visible on those two specimens.) Sides of head pale gray, lighter on labials, except for an ill-defined dark brown line extending posteriorly from orbit to a point one scale-width above angle of mouth. Ventral surface of head and throat cream, mental and first five infralabials clouded with pale gray.

Dorsal pattern of neck and body an irregular combination of a pair of narrow, dark brown stripes, each 1 to 3 scales wide, one on each side of the midline, and two coalescing series of long, narrow spots, fusing together now longitudinally, then transversely, forming interrupted stripes anteriorly, a zig-zag or reticulate pattern toward the posterior part of the body, and coming together to form a tapering, middorsal stripe on tail, where distally it breaks up into indistinct spots. (Cf. color pattern of paratypes, Fig. 2, 3.) The stripes and/or spots are darker at the borders and lighter in the centers. The median dorsal scales are somewhat lighter than those of the sides, giving the effect of a pale middorsal stripe, more distinct toward the middle of the body. The median stripe-spot pattern is only 6 to 8 scales wide overall. There is no pattern on the sides.

Paratypes. Both paratypes are similar to the holotype in all significant details. USNM 137286 (Fig. 2), female, has two small, granular scales between lower anterior corner of loreal and upper posterior tip of first supralabial ; one small scale between anterior tip of subocular and posterior end of subfoveal. Supralabials 8-8 ; infralabials 15-14. Scale rows 33-35-24 ; ventrals 231 ; subcaudals 81, all divided. Total length 1535 mm. ; tail 230 mm., apparently complete but terminal spine missing. Tail/total-length ratio . 150.

Dorsal pattern of head dark brown, more distinct than that of holotype. Muzzle between canthal plates generally dark, two subovoid spots faintly distinguishable. A pair of subelliptical spots just inside supraoculars ; midfrontal area dark. In parietal area a pair of centrally located, kidney-shaped spots ; back of these a median subcircular blotch, and lateral to these another pair of elongate-oval spots, diverging slightly posteriorly. In the postparietal area a pair of club-shaped bars extending backward, diminishing in width, from near midline to sides of head at an angle of about 45 degrees. Two longer club-shaped bars extend posteriorly from back of head to neck, where they converge. A distinct dark line, slightly more than one scale wide, from orbit backward and downward to a point one scale-width above last supralabial. Pattern of

body essentially similar to that of holotype. Spots on tail more distinct. No pattern on sides. Ventral surface with faint, subcrescentic, gray spots laterally, a pair on each ventral scute ; not present in neck and anterior body region, but becoming more pronounced posteriorly.

CNHM 74895 (Fig. 3), female, has 2 to 4 small granular scales between subocular and subfoveal. Supralabials 9-9 ; infralabials 15-15. Scale rows 33-35-24; ventrals 230 ; subcaudals 82, all divided. Total length 1125 mm.; tail 160 mm., terminal spine present. Tail/total length ratio . 142.

Dorsal pattern of head resembling that of USNM 137286, except that there is no median spot in the parietal area, and the club-shaped post-parietal bar on the left side coalesces with the left bar on the neck. Pattern of body fundamentally the same as described above but more distinct, and with somewhat more frequent transverse coalescence of the long, narrow blotches to form a pattern of elongate frets back and forth across the midline. No pattern on sides. Ventral surface yellowish, almost immaculate ; only faint traces of gray at ends of the more posterior ventral scutes.

Comparison with *T. f. flavoviridis* (Hallowell, 1860)

For comparative purposes I have examined the following 20 specimens of *flavoviridis* :

USNM 7512	Riu Kiu Islands, W. Stimpson
USNM 31818*	Amami, Oshima, Osumi, Hugh M. Smith
USNM 121468-71	Okinawa, Naha Middle School, May 20, 1945, J. H. Stover
USNM 121549-51	Okinawa, Hamahika-shima, May 17, 1945, H. G. Taylor
USNM 122165-7	Okinawa, 1945, Wm. B. S. Thomas
USNM 123030	Okinawa, Chijuka, Sept. 19, 1945, David H. Johnson
USNM 123312	Okinawa, Hentona, Sept. 22, 1945, O. A. Muennink
USNM 123313	Okinawa, Hentona, Sept. 2, 1945, O. A. Muennink
USNM 123882	Okinawa, June, 1945, Robert Rieman
USNM 129429	Okinawa, Oct., 1945, Wm. B. S. Thomas
USNM 137287-8	Kume Shima, Aug., 1945, Ernest R. Tinkham
CNHM 74896	Okinawa, Oct., 1945, James A. Slater

*Described in detail by Stejneger, 1907, p. 476.

It is not certain that these are the actual specimens obtained on Kume Shima by Dr. Tinkham. I was told that these snakes had been put in a zoo cage together with a considerable number of *flavoviridis* from Okinawa, and that the keeper had some hesitancy in picking out the two from Kume. Slight differences in coloration common to these two, however, appear to set them apart from the other specimens from Okinawa listed above.

With the exception of minor, and probably insignificant, variations in some of the small scales of the head, the scutellation of these twenty specimens is remarkably constant. Scale rows at midbody are 35 in fourteen individuals, 33 in five, and 34 in one. Ventrals in 11 males range from 221 to 236 (av. 229) ; in 8 females 226 to 237 (av. 229). Subcaudals, 11 males, 81 to 94 (av. 86) ; 6 females 78 to 84 (av. 80). Supralabials (2 counts per specimen) 7 to 9 (percentages: 7-5 ; 8-60 ; 9-35). Infralabials (2 counts per specimen) 14 to 17 (percentages: 14-17.5 ; 15-35 ; 16-42.5 ; 17-5) .

In all these characters the specimens of *tinkhami* fall within the range of variation here indicated, and close to the averages. It is apparent that no significant structural differences exist. It is in the color pattern that divergence is notable.

A salient characteristic of *flavoviridis* from Okinawa is heavy pigmentation. The general ground color is straw to pale yellow, even in specimens that have been preserved in alcohol for some years. The dark brown or blackish brown pattern of the head is sharply defined and conspicuous (Fig. 4). A pair of bars extend backward from the tip of the snout, mesiad to the enlarged canthals, and curve outward almost at a right angle in front of the supraoculars. These are followed by a longer pair of bars, each of which expands laterally onto the posterior ends of the supraocular and extends backward to a point above the angle of the mouth. Between these is a V-shaped figure with apex pointed anteriorly, sometimes with sides interrupted and sometimes closed by a crossconnection posteriorly. Posterior to this figure a pair of broad bars extend backward, diverging widely, from the occipital region to the posterior sides of the head. A sharp, dark line, one to two scales wide, extends from the orbit above the supralabials and lower temporals to the posterior angle of the jaw (Fig. 4, 5).

The middorsal pattern of the neck and body consists of a series of irregular dark brown or brownish black blotches, deeply incised medianly both anteriorly and posteriorly, giving the effect of a pair of irregular spots fused together at the midline. Each of these, for the most part, has a lighter central area which sometimes extends across the midline to meet its counterpart on the other side. These blotches are so exceedingly irregular, and coalesce with one another in such various combinations, that they defy description in commonly used terms and are impossible to count as distinct units. A rough estimate indicates a number between 40 and 50 on the body. The tail proximally bears spots similar to those of the body; distally the spots become irregular crossbands, the two together ranging roughly from 13 to 22.

In contrast to *tinkhami*, the sides of the body are heavily pigmented (Fig. 5). In some specimens the dark pigment takes the form of indistinct, elongate spots in two or three longitudinal rows, the lowermost becoming an interrupted stripe ; in others there is no discernible form ; in still others, especially in large and long-preserved individuals, the lateral pigment is diffuse or faded.

The ventral surface has little pigmentation anteriorly, hut from about midbody backward is clouded, marbled, or irregularly blotched with grayish brown, especially along the sides (the outer ends of the ventral scutes), the dark blotches becoming more distinct on the underside of the tail.

The two specimens of *flavoviridis* from Kume Shima are similar in general to those from Okinawa but somewhat lighter in tone, both as to ground color and pattern, although this to some extent may be due to differences in preservation. The lighter areas within the blotches of the middorsal series have a more frequent tendency to coalesce with one another across the midline, and the dark lateral pigmentation is more diffuse. The ventral spotting is fairly conspicuous in one, nearly absent in the other.

Comparison with *T. f. tokarensis* (Nagai, 1928)

A striking parallelism appears in *T. f. tokarensis*, first described by Nagai (1928) from Takarashima, Tokara Group, and redescribed and figured by Maki (1931, p. 233, fig. 158, pl. LXXXV). This form differs from *T. f. flavoviridis* in a notable reduction in the elements of the color pattern, both on the body and on the head, a lower number of scale rows, and a lower number of ventrals and subcaudals. The pattern of the body consists of two rows of black-rimmed, elliptical or subcircular spots along the middle of the back, the spots of the two series generally alternating with each other, but in places confluent into a single series of irregular spots ; the number of spots in one series 33 on the body and 21 on the tail ; an additional series of small spots in contact with the dorsal ones on each side of the posterior half of the body ; underside pale, with a series of dark brown blotches on each side (Maki, 1931).

Maki's text (English translation) does not describe the pattern of the head but his figures indicate no special markings on the muzzle and but two pairs of longitudinal bars on the frontoparietal and postparietal areas. Each of the more anterior bars appears to expand slightly at the mesioposterior edges of the supraoculars and then extend directly backward across the parietal area. The posterior pair lies closer to the mid-line, between the bars of the anterior pair, and each bar extends from

the parietal area backward and outward in a gentle curve ending in the postparietal region, not diverging sharply as in *flavoviridis* and *tinkhami*, nor reaching the posterolateral angle of the head.

Data on ventrals and subcaudals are included in Table I.

Table I. Comparison of some structural characters in three forms of *Trimeresurus flavoviridis*.

	<i>tinkhami</i>	<i>flavoviridis</i>	<i>tokarensis</i> *
Scale rows	35	35	31
Ventrals	♂ 226 ♀ 230, 231	11 ♂ 221-236 (229) 8 ♀ 226-237 (229)	8 ♂ 203-208 (205) 4 ♀ 203-209 (206)
Subcaudals	♂ 84 ♀ 81, 82	11 ♂ 81-94 (86) 6 ♀ 78-84 (81)	5 ♂ 76-83 (82) 3 ♀ 74-78 (76)
Tail/Total-length ratio	♂ .159 ♀ .150, .142	9 ♂ .153-.176 (.164) 4 ♀ .143-.169 (.154)	5 ♂ .17-.18 (.17) 5 ♀ .15-.16 (.16)

* Data from Maki (1931)

Maki has noted the similarities of *tokarensis* to *flavoviridis* and logically concluded that the former should be recognized as a subspecies of the latter.

The point of interest here, if it be assumed that *flavoviridis* is the parent form, is that *tokarensis* and *tinkhami* have diverged from it in a similar manner as to coloration: in reduction in the overall amount of pigmentation, restriction of the pattern of the body to the region of the midline, reduction or loss of pattern on the sides, reduction of ventral pattern, and modification of the pattern of the head along different lines. Structurally, *tokarensis* has diverged farther, as mentioned above and indicated in Table I.

Geographic Considerations

The geography and geology of the Riu Kiu Islands have been reviewed by Inger (1947, p. 298-304; 1950, p. 95-101). As he has pointed out, these islands extend in a great arc, convex southeastward, between the East China Sea and the Pacific Ocean, from south of the large Japanese island of Kyushu to a point northeast of Formosa. In position these islands lie in two curves: an inner, or western, curve of volcanic origin, including the Tokara Group, Kume, and several other small islands to the northeast of Formosa; and an outer, or eastern, curve

including all the others (the larger Okinawa, Amami, *et al.*) which are remnants of the ancient Riu Kiu Cordillera (late Permian or early Mesozoic). Subsequent to the Eocene there have been many fluctuations in sea level and as many as three periods of notable land emergence : during the Oligocene, the late Pliocene, and the earliest Pleistocene. During these fluctuations Kume was one of the several islands most subject to inundation. Since the early Pleistocene there have been additional minor fluctuations in sea level, and in one of these the larger islands including Okinawa and Amami were connected with their dependent islets.

In view of these historical considerations and the morphological data noted in the study of these snakes, it seems a logical hypothesis to regard *T. f. flavoviridis* as an older and more generalized population from which both *tokarensis* and *tinkhami* have been derived. It is apparently endemic to two of the larger, older, and more stable islands, Okinawa and Amami. During one or another of the periods of land emergence, when these islands were connected with the smaller islets, the ancestral population of *flavoviridis* could have gained access to Takara, Kume, and others. By reason of the greater amount of morphological divergence, *tokarensis* appears to have had the benefit of a longer period of isolation on Takara than *tinkhami* has had on Kume.

The apparent occurrence of *flavoviridis* on Kume, alongside of the conspicuously different *tinkhami*, poses another problem. On the basis of presently limited knowledge and material, it can be suggested that a secondary invasion of *flavoviridis* from Okinawa may have occurred, either fortuitously or during the last period of Pleistocene land emergence. There is some evidence (Rosenthal, 1948 ; Slater, 1946, 1948) that *flavoviridis* on Okinawa occurs in the coastal lowlands, but whether it also occupies higher elevations is not indicated. If *tinkhami* is primarily a highland form and *flavoviridis* a lowland form, the existence of some kind of ecological isolation may be postulated ; and, if such a distribution prevails on Kume, it supports the suggestion that the latter is a recent reinvader of the islet.

Acknowledgments. For the loan of material, and for advice, criticism or other assistance, I am grateful to Dr. Doris M. Cochran, U. S. National Museum ; Dr. Robert F. Inger, Chicago Natural History Museum ; Dr. William M. Mann, National Zoological Park ; Dr. Ernest R. Tinkham, Indio, Calif.; and Dr. Joseph H. Camin, Chicago Academy of Sciences.

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